Canadian Aviation Safety Board

Bureau canadien de la sécurité aérienne

Civil Aviation Occurrence Report

Canada

89-03482/

The Canadian Aviation Safety Board investigated this occurrence for the purpose of advancing aviation safety. It is not the object of the Board to determine or apportion any blame or liability.

AVIATION OCCURRENCE REPORT

AIR TORO INC.
DE HAVILLAND DHC-2 BEAVER C-GDZE
LAKE MONDONAC, QUEBEC
24 JUNE 1987

REPORT NUMBER 87-H70002

SYNOPSIS

The pilot of the float-equipped aircraft departed the company's base in St. Ignace-du-Lac, Quebec for a visual flight to Lake Garancière, Quebec. While approaching the half-way point to destination, the pilot manoeuvred the aircraft in a series of turns close to the ground. The aircraft descended and struck the ground in a steep, nose-down, left-wing-low attitude. The pilot and three of the passengers were fatally injured. The passenger sitting next to the pilot was seriously injured. The aircraft was destroyed by impact and by a signal fire started by the surviving passenger approximately six hours after the accident.

The Canadian Aviation Safety Board (CASB) determined that the aircraft was loaded beyond the specified weight and centre of gravity limits. It is probable that the pilot lost control of the aircraft while attempting a precautionary landing.

Ce rapport est également disponible en français.

16 December 1988

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1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 24 June 1987, the pilot of the float-equipped DHC-2 Beaver departed the company's base in St. Ignace-du-Lac for a one and a half hour visual flight rules (VFR)* flight to transport four fishermen and their equipment to Lake Garancière, 103 nautical miles to the north northwest.

Following take-off, the aircraft climbed and levelled off at approximately 2,000 feet above sea level (asl)**, approximately 900 feet above ground level (agl). After the aircraft had levelled off, the passenger, who was sitting next to the pilot and who had flown in a Beaver aircraft on three occasions, noticed that the aircraft was flying in a slightly nose-up attitude. The nose-up attitude of the aircraft was such that it prevented the passenger from seeing the horizon out the front window without leaning forward. The surviving passenger stated that the aircraft was also flying in a slightly right-wing-down attitude.

Nearing Lake Mondonac, the pilot commenced a series of turns. During these manoeuvres, the passenger noticed that the altimeter was reading 1,700 feet asl and estimated that the aircraft was flying between 200 and 300 feet agl.

The aircraft descended and struck the ground in a steep nose-down, left-wing-low attitude. The aircraft was destroyed by the impact, and the wreckage was consumed by a signal fire which was started by the surviving passenger approximately six hours after the accident. The crash occurred 42 nautical miles north northwest of St. Ignace-du-Lac and one-quarter mile west of Lake Mondonac (see Appendix A).

The accident occurred at lat 47°25'N, long 74°00'W at approximately 1230 EDT*** during the hours of daylight, at an elevation of 1,375 feet asl.

* See Glossary for all abbreviations and acronyms.
** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.
*** All times are EDT (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	3	-	4
Serious	-	1	-	1
Minor/None	-	-	-	-
Total	1	4	-	5

1.3 Damage to Aircraft

The aircraft was heavily damaged at impact, and the wreckage was consumed by a signal fire started by the surviving passenger approximately six hours after the accident.

1.4 Other Damage

- Nil -

1.5 Personnel Information

	Pilot-In-Command
Age	58
Pilot Licence	Commercial
Medical	Valid with required glasses
Total Flying Time	625 hr (estimated)
Total on Type	85 hr (estimated)
Total Last 90 Days	20 hr (estimated)
Total on Type Last 90 Days	20 hr (estimated)
Hours on Duty Prior to Occurrence	4 hr
Hours off Duty Prior to Work Period	15 hr

1.5.1 Background of the Pilot

The pilot, who was the owner and the chief pilot of Air Toro Inc., conducted an outfitting business from the months of May to November between St. Ignace-du-Lac and seven hunting and fishing camps using a float-equipped Cessna 180 and the Beaver. Another pilot flew approximately 70 per cent of the flights, while the owner assumed the rest of the flying duties on a part-time basis.

The pilot obtained his float endorsement in 1979 and had accumulated approximately 500 hours flying float-equipped aircraft. The company purchased the Beaver in July 1984, and the owner received training from the other company pilot who was well experienced on this aircraft type.

1.6 Aircraft Information

Manufacturer	de Havilland of Canada
Type	DHC-2 Beaver
Year of Manufacture	1952
Serial Number	437
Certificate of Airworthiness	Valid
Total Airframe Time	6,294 hr
Engine Type	Pratt & Whitney R985-AN1
Propeller Type	Hamilton Standard 2D30-301
Maximum Allowable Take-off Weight	5,090 lb
Recommended Fuel Type	80/87

The aircraft was certified and maintained in accordance with existing regulations and approved procedures. The Technical Log Book did not accurately reflect the time accrued on the Beaver. An accounts book related to pilot pay for hours flown revealed that the aircraft had been operated in excess of the times reported in the Technical Log Book. The Beaver had been operated for approximately 360 hours since purchased by Air Toro Inc. The Journey Log Book was not recovered. It was most likely destroyed by the fire following the accident as the pilot was known to carry this document on every flight.

The pilot flew the aircraft to Lake Garancière four days before the accident flight, and a passenger on that flight had not noticed anything unusual about the floats, nor had he noticed anything unusual about the flying characteristics of the aircraft. The aircraft then remained on the water for four days before the accident flight.

Some of the camps operated by the company did not have docking facilities. The Beaver was backed onto shore for loading and unloading purposes. This procedure was also used at Lake Garancière.

1.6.1 Weight and Balance

The pilot had filled out a company weight and balance form before the flight. The weight of the passengers on the document did not reflect their actual weights or the standard occupant weights suggested by Transport Canada. By comparing the actual weights of the occupants with the total estimated occupant weight of 804 pounds presented on the weight and balance documents, it was determined that their weights had been understated by a total of 91 pounds.

The pilot had entered on the weight and balance form a cargo load of 197 pounds. The fishermen's cargo was not weighed before it was loaded on board the aircraft and was destroyed in the post-impact fire. The fishermen were leaving for a four-day holiday, and the cargo area behind the centre seat was filled to the extent that the occupants' baggage was piled near or to the aircraft ceiling. The actual weight of the cargo could not be determined. A survey was conducted to determine what four fishermen venturing out in a Beaver aircraft might bring with them to cover a four-day period. A typical cargo load weighed 474 pounds.

Before the passengers arrived at the base for the flight, the pilot had fuelled the aircraft. The standard fuel load for a flight to Lake Garancière consisted of filling the front and centre fuselage tanks to capacity and the rear fuselage tank to half capacity. The fuel load of 68 Imperial gallons provided adequate fuel for the return trip, including the required fuel reserve. The pilot was known to follow the manufacturer's recommended procedure of first selecting the rear tank. As fuel was depleted from the rear tank, the centre tank would be selected before the front tank.

After the cargo had been loaded on board the aircraft for the flight to Lake Garancière, the surviving passenger overheard the pilot say that the aft section of the right float appeared to be low in the water but that it would not pose any problems. The occupants had not boarded the aircraft at that point, and the surviving passenger noticed that the water level was at or near the top of the aft section of the right float. No known observations were made of the left float. It was not known if the pilot had pumped the floats although it was company practice to do so.

The pilot had indicated on the company weight and balance form that the take-off weight was 4,984 pounds or 106 pounds under the maximum allowable take-off weight of 5,090 pounds. Using the weight of the occupants, 474 pounds of cargo, and the fuel load, it is estimated that the aircraft weighed 5,372 pounds or 282 pounds over the maximum allowable take-off weight. The aircraft was 388 pounds heavier than the weight calculated by the pilot.

The company weight and balance form did not allow for the calculation of the centre of gravity position of the loaded aircraft. For this aircraft, the forward centre of gravity limit is located at -1.25 inches aft of datum, and the aft limit is located at -6.1 inches aft of datum. The centre of gravity was estimated by the aircraft manufacturer to be located at -6.52 inches aft of datum or 0.42 inches aft of the specified limit.

It was estimated that the flight lasted approximately 45 minutes and that 110 pounds of fuel had been consumed at the time of the accident.

The other company pilot, who did not make use of a weight and balance form, indicated that he never weighed cargo placed on board the Beaver; he relied on the water level observed at the rear of the floats. When the water level reached approximately five inches below the top of the aft portion of the floats, the company pilot stopped loading the aircraft. The company's operation manual stipulated that the aircraft weight and centre of gravity had to be determined before each departure.

1.6.2 Aircraft Flight Characteristics

Without the appropriate selection of flaps, the aircraft climb capabilities may be substantially reduced and may become negligible especially if the aircraft is heavily loaded. The manufacturer recommends a specific flap setting for take-off and another for climb. When flying straight and level, the manufacturer recommends retracting the flaps. However, Beaver pilots have indicated that extending the flaps two or three degrees while in cruise lowers the nose of the aircraft and permits a slight increase in airspeed. The pilot was familiar with the recommended flap operating procedures; however, it could not be determined if flaps were used throughout the flight until the final manoeuvres. Shortly before or during the final manoeuvres, the survivor noticed the pilot operating the flap handle.

No engine operating irregularities were reported by the surviving passenger.

The manufacturer was unable to provide specific details pertaining to the flight characteristics of the aircraft given the estimated load and the centre of gravity aft of the specified limit. Although the maximum take-off weight had been exceeded, according to the manufacturer and experienced Beaver pilots, the aircraft should have been able to climb to the altitude normally flown by the pilot, which ranged between 4,000 and 5,000 feet asl when flying to and from Lake Garancière.

With the centre of gravity located aft of the specified rearmost limit, the aircraft's longitudinal stability will be reduced, and the aircraft may tend to pitch nose-up as the power is reduced. This pitch-up tendency is further aggravated if the flaps are lowered. The pitch control will feel unnaturally sensitive in certain configurations, that is, the amount of force required to displace the elevator control will be reduced and there will be a marked tendency to overcontrol. The pilot may not be able to adjust his technique for the unnatural feel and response of the aircraft. The aircraft may also possess abnormal stall characteristics; recovery may be difficult, and, if the aircraft is near the ground, the result could be catastrophic.

1.6.3 Carburettor Heat

The pilot/owner had received instruction on the operation of the carburettor heat system from the other company pilot. The aircraft was equipped with a carburettor temperature gauge, and the aircraft manufacturer recommends maintaining the carburettor temperature air mixture between four and seven degrees Celsius. The application of full carburettor heat will result in a reduction of power. During periods of high power output demand such as during take-off and climb, aircraft performance will be reduced, especially if the aircraft is being operated at or close to its maximum allowable take-off weight. The application of full carburettor heat may cause the high limit of the carburettor inlet air temperature to be exceeded. As a result, detonation, overheating, and engine damage is likely to occur.

The pilot/owner had acquired most of his experience flying the Cessna 180 which was equipped with a carburettor heat control that is normally operated in either the full cold or the full hot position. The application of full carburettor heat is included in the pre-landing check of the Cessna 180.

1.7 Meteorological Information

An automatic weather reporting station, located 40 miles to the northwest of the accident site and close to the track normally flown to destination, reported clear conditions below 5,000 feet and a visibility greater than nine miles. The temperature was 27 degrees Celsius, and the dew point was 14 degrees Celsius. A few cumulo-type clouds and some towering cumulus with tops to 15,000 feet were present along the route. The winds were blowing from the west at approximately 10 knots.

According to the carburettor icing chart published in Transport Canada's Aeronautical Information Publication, with the temperature and dew point relationship, the pilot should have expected serious carburettor icing with the engine producing descent power.

1.8 Aids to Navigation

The pilot had flown to Lake Garancière from St. Ignace-du-Lac on numerous occasions and was familiar with Lake Mondonac, which is a large lake suitable for landing.

The terrain elevation gradually increases from the operator's base to Lake Garancière reaching 2,000 feet asl in certain areas before arriving at Lake Garancière.

The aircraft appeared to be flown straight to destination until the final manoeuvres. A VFR Navigation Chart was recovered from the wreckage, and the accident site was located on the track line drawn to destination.

1.9 Communications

The company operated a very high frequency (VHF) and a high frequency (HF) transceiver at the base in St. Ignace-du-Lac. The aircraft was equipped with a serviceable VHF transceiver, and the installation of an HF unit was in progress but had not been completed. The pilot had left his headset at the base and, consequently, could not receive any communications. The passenger sitting next to the pilot did not observe the pilot using a microphone, nor did he see one available in the cockpit. The company's operation manual stipulated that the aircraft was to be equipped with a serviceable HF radio to maintain contact with the base.

1.10 Aerodrome Information

- Not applicable -

1.11 Flight Recorders

The aircraft was not equipped with a flight recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

1.12.1 Accident Site

The accident site was located in a wooded area approximately one-quarter mile west of Lake Mondonac. The general area was relatively flat with medium-sized trees. The ground was spongy and muskeg-like in the immediate area of the accident site. Based on the tree cut angles at the site, the aircraft descended in nose-down attitude of about 46 degrees and in a left-wing-low attitude of approximately 44 degrees on a heading of 304 degrees magnetic (M). The aircraft struck the ground on a heading of 268 degrees M and pivoted on its nose to the left. The right aft portion of the fuselage struck a tree sideways, and the aircraft came to rest on level terrain in a slightly right-wing-low attitude, 14 feet from the initial point of ground contact. The final fuselage wreckage orientation was 221 degrees M.

1.12.2 Aircraft Wreckage

The aircraft had remained relatively intact after the accident. Both wings remained partially attached to the airframe, and the left wing was swept back slightly. The fire destroyed the single flap actuator; however, the flap indicator showed a setting between take-off and landing. Such a flap setting on a Beaver is normally used while on approach to land. The empennage was relatively intact, and the elevator screw-jack was found in a nose-down position. The engine was separated from the airframe, and some wiring from the firewall was still attached to the engine.

A fire which was started near the aircraft by the survivor consumed the aircraft from the firewall to an area aft of the cabin. In those portions of the aircraft which were not consumed by fire, there was no evidence of any structural failure of the aircraft beyond the damage attributable to the collision with trees and the subsequent ground impact.

The front left float dug 20 inches into the ground and was sheared ahead of the front spreader bar. The floats separated from the aircraft and were damaged at impact and by the fire except for the aft sections which remained relatively intact. The aircraft was equipped with EDO 4580 floats. Each float is divided into five separately sealed compartments with individual bilge pump openings. The aft compartment of the right float and the two rearmost compartments of the left float, which had remained in reasonable shape following the accident, had come to rest in an upright position on the ground. During recovery of the floats, a small amount of water was present in the aft compartment of the right float. The amount of water was not determined.

1.13 Medical Information

1.13.1 Autopsy and Toxicological Analysis

According to the autopsy and toxicological findings, there was no evidence that incapacitation affected the pilot's performance. The pilot, who survived the immediate impact, died later as a result of head injuries. Because of the severe post-impact fire, autopsies could not be performed on the other victims.

1.13.2 Pilot's Behaviour

On the morning of the accident, the pilot appeared relaxed and well-rested. There was no evidence that the pilot was in a hurry to complete the flight. He did not give any indications that there was something wrong, except for the uncertain look displayed on his face during the final manoeuvres. The pilot did not talk to the passengers throughout the flight. He did not appear to make any power changes after the aircraft was levelled off. There were no known psychological factors which could have affected his performance.

During the final manoeuvres, the surviving passenger noticed that the pilot appeared to be concerned about something.

1.14 Fire

Approximately six hours after the accident, the surviving passenger, who could only move himself with great difficulty because of his injuries, decided to light a fire near the wreckage hoping to draw the attention of the occasional passerby travelling on a nearby road. The fire was started aft of the left wing close to the fuselage. The fire quickly spread to the cabin and burned for several hours. The damp condition of the ground prevented the fire from spreading further than the immediate vicinity of the aircraft. Once the fire had started, the survivor crawled away from the aircraft and awaited rescue.

1.15 Survival Aspects

1.15.1 Seat-Belts/Restraints

The impact was survivable. The floats, which separated from the aircraft on impact and the spongy ground helped reduced the deceleration forces imposed on the cabin structure. The cabin area sustained relatively little crushing as a result of the impact. The nature of the survivor's injuries were indicative that the deceleration forces imposed on the cabin structure were within human tolerance. The front-seat occupants used the seat-belts. The pilot was projected outside the aircraft and received fatal injuries. It could not be determined whether the seat-belt attachment or the seat-belt failed. The right seat-belt used by the survivor held through impact. The three rear-seat passengers used the seat-belts, which also held through impact. The extent of the injuries sustained by the rear-seat occupants could not be determined.

No shoulder harnesses were available. The survivor suffered serious facial injuries when he struck his head on the instrument panel.

1.15.2 Seats and Anchorages

Because of the fire damage, it could not be determined whether the seats held through the impact.

1.15.3 Cargo Restraints

The cargo had been placed behind the rear passenger seat and was piled to or near the cabin ceiling. No cargo restraint system was available. Some of the cargo was projected outside the aircraft on impact and may have struck some of the occupants. The load consisted of coolers, food supplies, tackle boxes, and other fishing gear.

1.15.4 Passenger Briefing

The passengers were not briefed on the use of safety or emergency equipment prior to departure, nor were there any briefing cards available in the aircraft. Air Navigation Order (ANO) VII, No. 3 stipulates that an operator must inform the occupants with respect to the emergency equipment on board the aircraft.

1.15.5 Emergency Locator Transmitter (ELT)

The aircraft was equipped with an ELT (Narco 10) which activated on impact. The survivor was not aware that the Beaver was equipped with an ELT.

1.15.6 Search and Rescue

At 1338 EDT, the Search and Rescue Satellite (SARSAT) received an ELT alert. The Search and Rescue Coordination Centre, located in Trenton, Ontario, received the distress message at 1352 EDT. At 1444 EDT, the first of two aircraft was dispatched to the signal area. The aircraft was flown over an image position located 210 miles from the site of the accident. The signal area was positively identified, and the second SAR aircraft was dispatched to the area at 1625 EDT. The rescue efforts were delayed since thunderstorm activity prevented the aircraft from flying directly to the signal area. While en route, the SAR personnel lost the ELT signal. This likely occurred as a result of the fire which destroyed the ELT. The SAR crew noticed the smoke from the burning wreckage and arrived at the accident site at 2013 EDT.

1.16 Tests and Research

1.16.1 Engine and Propeller

The engine and propeller were recovered and forwarded to the CASB Engineering Laboratory for examination. The engine mount, control cables, and fuel and oil lines were severed; the engine remained attached to the firewall by some wiring. The condition of the rotating components was indicative of low levels of power at the time of impact. The carburettor heat valve was found in the full-heat position, indicating that the carburettor heat control had been selected in that position.

When the engine starter was removed, a shop rag could be seen inside the rear case wrapped around the right-hand gear assembly and the auxiliary vertical drive. When the engine rear case was removed, it was found that the rag was fragmented and parts were wrapped around the oil pump drive gear. A large amount of the shop rag was recovered from around the vertical shaft. There was no indication that any of the pieces of the rag had entered the oil pressure system of the engine. It appeared that the rag would not have affected the operation of the engine or the function of the engine instruments.

The engine was assessed as being in good overall condition and capable of producing power. The propeller was still attached to the engine, and one blade was bent backward slightly. The pitch angle was determined to be in a fine-pitch position. The damage to the propeller was also indicative of low power at impact.

1.16.2 Fuel Selector

The fuel selector handle and the fuel selector valve were recovered and forwarded to the CASB Engineering Laboratory for examination. The fuel selector handle was still attached to the instrument panel by the control cable. The handle had been forced and was stuck at the physical stop in the OFF position. The fuel selector valve was recovered but had been severely damaged in the fire. The position of the fuel selector valve and handle at impact could not be determined.

1.16.3 Engine Oil and Fuel Analysis

Samples of fuel obtained from the operator's base reservoir and engine oil were forwarded to the National Research Council's (NRC) Fuel and Lubricants Laboratory for analysis. The oil sample contained approximately 6 per cent water in an emulsified state. The most likely source of the water was considered to be condensation. No other contamination was detected in the oil sample. The water would not have had an adverse effect on the performance of the engine.

The results of the fuel analysis were compared to the criteria established by the Canadian General Standards Board. The fuel met the criteria for volatility at the cruise and full-throttle power setting ranges. However, the fuel did not meet the criteria at the lower power setting. This would have resulted in the engine being hard to start and would have caused rough engine idling.

The gum content in the fuel was higher than the maximum specified value. However, the gum content was completely soluble in n-heptane and was typical of a petroleum-based oil product. Since the gum was completely soluble, it would have readily washed through the engine and would not have affected the engine's performance.

1.16.4 Instruments

The flight and engine instruments were severely damaged and burnt. Some of them were recovered and forwarded to the CASB Engineering Laboratory for examination. The only instrument which could provide any information was the airspeed indicator which was reading 51 knots. It could not be determined if the reading was representative of the aircraft's indicated airspeed at impact.

1.16.5 Floats

During examination of the aft compartment of the right float at the CASB Engineering Laboratory, a one-inch crack was noted near a keel rivet. The crack was determined to be of a pre-impact nature. No other punctures were noted. The crack was such that it would have permitted water to seep into and escape from the compartment at a slow rate. During testing of the float unit, the water drain rate was established at approximately 100 millilitres per hour or approximately one-quarter pound per hour.

By performing weight tests with an aircraft similar to the accident aircraft, the amount of water required to lower the right float into the water to the level observed by the survivor was determined to weigh approximately 160 pounds. This weight was also consistent with the volume of water required to fill the aft compartment to the level of the water stain line on the outside of the float. The stain lines appear on the side of the floats over a prolonged period as the aircraft remains idle on the water and are usually representative of the aircraft weight, excluding its payload. With all other float compartments intact, the buoyancy of the float is likely to limit the water entering the compartment to the level of the stain line on the outside of the float.

Many of the keel rivets on both float sections recovered were scraped and worn. Such wear to keel rivets is consistent with that which occurs when float-equipped aircraft are backed onto the shore.

1.17 Additional Information

1.17.1 Regulatory Overview

The company's operation manual did not include the weight and balance forms for the Beaver at the time Transport Canada amended the operator's Operating Certificate (OC) for the operation of the aircraft. Following a base inspection in June 1985 by Transport Canada's Air Carrier personnel, Air Toro Inc. was informed in writing that sample forms were required to ensure that the weight and balance of the company's two aircraft were within limits. The company owner did not respond to this request, and there was no follow-up by Transport Canada.

According to Transport Canada's air carrier flight operations rating system, Air Toro Inc. met most requirements, but corrective action in the following areas was required within a specific time frame as a result of the base inspection in August 1986:

- It was noted by Air Carrier personnel that the flight and ground training of the two pilots at the beginning of the season could be more "serious." According to the base inspection document, each company pilot had completed one hour of flight training in May 1986.

- The company documents were reviewed by Air Carrier personnel, and the company operations manual needed to be amended. There was no weight and balance form available for the Beaver. It was also noted that records of the pilots' licences, medical validation certificates, and initial and recurrent training had to be maintained.

- The record keeping for the carriage of dangerous goods needed improvement.

- The company was informed in writing to rectify the discrepancies and to detail in writing the corrective actions taken before 30 September 1986. There was no mention in Transport Canada's letter to the company that the record keeping for the carriage of dangerous goods needed to be improved.

The pilot/owner replied to Transport Canada in writing in October 1986 that he had complied with the request following the last base inspection. There was no mention of how each discrepancy was resolved, nor were any copies of the weight and balance forms for the DHC-2 sent for examination by Transport Canada officials. There was no follow-up by Transport Canada.

1.17.2 Canadian Transport Commission Licence

At the time of the accident, there was no insurance coverage for the Beaver as required under subsection 20.3(1) of the Canadian Transport Commission's (CTC)* Air Carrier Regulations (ACR). The CTC reported that, contrary to subsection 20.4(1), the CTC had not been informed that insurance coverage for the accident aircraft had been cancelled.

* As of 01 January 1988, the CTC was replaced by the National Transportation Agency.

2.0 ANALYSIS

2.1 Introduction

While proceeding en route and for reasons not expressed to the passengers, the pilot deviated from the planned flight and began manoeuvring the aircraft close to the ground. The impact attitude and the nature of the damage to the aircraft indicate that, during this manoeuvring, the aircraft stalled and entered a spin at an altitude from which a recovery could not be effected.

The investigation was principally concerned with determining the reason for the deviation from the intended flight and the subsequent stall. Particular attention was paid to the pre-impact condition of the aircraft, the weight and centre of gravity, and the aircraft flight profile. Also examined were certain aspects of the company's operations, the regulatory surveillance, and the adequacy of the aircraft restraint systems.

2.2 Aircraft Pre-impact Condition

There was no evidence of any pre-impact structural failure or aircraft system malfunction. All observed damage to the aircraft was directly attributable to tree and ground impact and the post-impact fire. Examination of the engine and propeller determined that the engine was in good condition and capable of producing power. Evidence indicated that sufficient fuel for the planned flight had been boarded. The extent and duration of the post-impact fire confirmed that a significant amount of fuel was on board the aircraft at the time of the accident.

Examination of the wreckage did, however, reveal the presence of a pre-existing crack near a keel rivet in the aft compartment of the right float. The crack was of sufficient size to permit the seepage of water into the float while the aircraft remained on the water. Although it was not possible to determine the cause of the rupture, the backing of the floats onto the shore to load and unload the aircraft at some of the company's camps may have caused or contributed to the cracking of the keel. This procedure was used at several of the operator's camps including the camp located at Lake Garancière.

2.3 Weight and Centre of Gravity Considerations

Contrary to the company's operation manual, the load control procedures were not followed. Although a weight and balance form had been completed by the pilot prior to commencing the flight, it did not accurately indicate the load on the aircraft.

It was not possible to determine the precise weight of the aircraft load; however, it was estimated that the weight of the aircraft, including the passengers, cargo and fuel, was 5,372 pounds, 388 pounds in excess of that calculated by the pilot and 282 pounds over the maximum authorized take-off weight. It was estimated that the centre of gravity position was located at -6.52 inches, 0.42 inches aft of the specified rearmost limit.

Based on the pre-departure observations of the aft section of the right float made by the surviving passenger and the nature of the crack found in the keel of the aft compartment, it was determined by weight and volume testing that there could have been 160 pounds of water in the right rear float section. If this was the case, the aircraft weight at take-off would have been approximately 5,532 pounds, 442 pounds over the maximum allowable take-off weight. The centre of gravity position was calculated to be located at -9.51 inches, 3.41 inches aft of the specified rearmost limit.

Based upon this hypothesis and applicable fuel consumption rates and assuming the pilot used the rearmost fuel tanks first, it is estimated that the aircraft weight and centre of gravity position at the time of the accident were 332 pounds over the maximum authorized take-off weight and 2.92 inches aft of the rearmost limit.

The aircraft would have been the least longitudinally stable immediately after take-off and during climb-out because of the aft location of the centre of gravity. Immediately after take-off, the aircraft would have displayed unusual flight characteristics, and the pitch control would have felt unnaturally sensitive.

The nose-high flight attitude described by the surviving passenger, combined with the nose-down setting of the elevator screw-jack, suggests that the weight and centre of gravity position adversely affected the aircraft flight characteristics.

The right-wing-low attitude of the aircraft described by the surviving passenger is indicative that the weight of the water in the aft compartment of the right float may have caused an imbalance in the load distribution of the aircraft.

2.4 Aircraft Flight Profile

It could not be ascertained why the aircraft was not flown at an altitude greater than 2,000 feet asl. Near destination, the terrain elevation in certain areas reached 2,000 feet asl. The altitude at which the aircraft was flown would not have provided a safe clearance above the rising terrain. Although the flap setting selected for the climb and the cruise segment of the flight could not be determined, a flap selection other than that recommended by the manufacturer could have affected the aircraft's climb capabilities, especially with the heavy load and the centre of gravity aft of the specified limit.

The proximity of the accident site to Lake Mondonac, which provided ample space for landing, and the positions/settings at impact of the flaps and propeller pitch indicate that the pilot had configured the aircraft for and was attempting a landing when the aircraft stalled.

It could not be determined why the pilot had selected full carburettor heat. The atmospheric conditions were not conducive to the application of full carburettor heat for cruise or manoeuvring power settings. It is unlikely the aircraft was flown with the carburettor heat control selected to full heat for an extended period of time as a prolonged application of full carburettor heat would likely have caused engine overheating and detonation. The surviving passenger did not report any engine operating irregularities, and the pilot did not give any indication that there was something wrong until the final manoeuvres. The pilot, who appeared to be under a certain amount of pressure during the final manoeuvres, may have selected full carburettor heat because most of his flight experience had been accrued flying the company Cessna 180 which included the selection of full carburettor heat before landing.

It is probable that the aircraft stalled because of control difficulties as a result of the aft location of the centre of gravity.

2.5 Company Operations

A number of factors present in this accident indicate that the operating procedures used by the pilot/owner were inadequate.

The pilot, who had not weighed the cargo, had inaccurately filled out a company weight and balance form that did not allow for the calculation of the centre of gravity position. The company carried out a commercial operation with the Beaver without the required liability or passenger insurance as stipulated by subsection 20.3 of the Air Carrier Regulations. The Technical Log Book did not accurately reflect the hours which had been accrued on the Beaver. Contrary to the company's operation manual, the aircraft was not equipped with the means to communicate with the company's base.

2.6 Regulatory Monitoring

In June 1984, Transport Canada had amended the company's OC to operate the Beaver and did not verify if the weight and balance form for the aircraft was included in the company's operations manual.

There was inadequate follow-up by Transport Canada despite the operator's failure to submit the required weight and balance form for the Beaver following the annual base inspections in 1985 and 1986.

The operator was not informed in writing that corrective action was required in the record keeping for the carriage of dangerous goods, nor was there adequate follow-up of the discrepancies noted by Air Carrier personnel following the company base inspection in August 1986.

2.7 Aircraft Restraint Systems

Had the pilot's seat-belt system held through impact and had shoulder harnesses been available and used by the front-seat occupants, their injuries would have been reduced. It could not be determined if the injuries sustained by the rear-seat occupants would have been reduced had shoulder harnesses been available and used. The lack of a cargo restraint system may have aggravated the occupants' injuries.

3.0 CONCLUSIONS

3.1 Findings

1. The weight and the centre of gravity of the aircraft exceeded the specified limits.

2. The aircraft's longitudinal stability was reduced.

3. The pilot attempted a precautionary landing for undetermined reasons.

4. The aircraft stalled at a height at which recovery was not possible.

5. The company load-control procedures were inadequate.

6. A crack in the keel of the aft compartment of the right float permitted water to seep into the float compartment.

7. Had the pilot's seat-belt system held through impact and had shoulder harnesses been available and used by the front-seat occupants, their injuries would have been reduced.

8. The lack of a cargo restraint system may have aggravated the occupants' injuries.

9. The company did not provide the occupants with information about the emergency equipment on board the aircraft, as required by ANO VII, No 3.

10. Contrary to subsection 20.4(1) of the Air Carrier Regulations, the CTC had not been informed that the insurance coverage for the Beaver had been cancelled.

11. Transport Canada amended the company's OC to operate the Beaver and did not verify if the aircraft weight and balance form was included in the company's operations manual.

12. The operator failed to submit on two different occasions the required weight and balance form for the aircraft following the base inspections in 1985 and 1986 by Transport Canada.

13. There was inadequate follow-up by Transport Canada of the discrepancies noted by Air Carrier personnel following the company's base inspections in 1985 and 1986.

14. The time accrued on the Beaver was in excess of that documented in the Technical Log Book.

15. The pilot was certified and qualified for the flight in accordance with regulations.

16. The aircraft was certified and maintained in accordance with regulations and approved procedures.

17. The aircraft was not equipped with the means to communicate with the company's base as stipulated in the company's operation manual.

3.2 Causes

The aircraft was loaded beyond the specified weight and centre of gravity limits. It is probable that the pilot lost control of the aircraft while attempting a precautionary landing.

4.0 SAFETY ACTION

4.1 Action Taken

4.1.1 Passenger Safety Information

The CASB issued recommendation CASB 88-01 as a result of the investigation into an accident involving a float-equipped aircraft at Dease Lake, British Columbia on 27 September 1986. This recommendation dealt with the need for air carriers operating float-equipped aircraft to carry out pre-flight passenger safety briefings. The Air Toro accident re-emphasizes the need to ensure that passengers are provided with pre-flight safety instructions, including briefing cards which depict escape routes and which provide information on the operation of such survival equipment as the ELT.

4.1.2 Shoulder Harnesses

The CASB has completed a study on the utilization of shoulder harnesses on small commercially operated and privately owned aircraft. The report (SP87-002) entitled "Study of the Influence of Shoulder Harnesses in Aviation Safety" contained two recommendations - specifically, the Board recommended that:

> The Department of Transport require the installation of shoulder harnesses, where practicable, in the flight crew seats of all small commercial aircraft, regardless of their date of manufacture; and
>
> (CASB 87-58)

> The Department of Transport institute a comprehensive program to promote the benefits of using shoulder harnesses and encourage the installation of shoulder harnesses in privately owned aircraft.
>
> (CASB 87-59)

4.1.3 Liability Insurance

The National Transportation Act, 1987 and the Air Transportation Regulations which came into force on 01 January 1988, now govern what insurance requirements need to be complied with by Canadian air carrier operators. The National Transportation Agency is responsible for ensuring that the new legislation with respect to air carrier liability insurance is complied with. Accordingly, the Agency has undertaken a number of related initiatives: new and additional filing

requirements have been imposed; insurance verification by the Agency's Enforcement Directorate has been stepped up; and closer relationships with the insurers of the air carriers have been developed. The Board believes that these measures will indirectly contribute to the overall safety of the Canadian aviation industry.

4.2 Action Required

4.2.1 Lack of Follow-up Action When Issuing an Operating Certificate

The circumstances of this occurrence indicate inadequacy in the methods by which Transport Canada (TC) amends Operating Certificates (OCs) and in the follow-up to observations made after a TC audit of a company's operations.

Air Toro was granted an amendment to its OC on 28 June 1984 enabling the operation of Class IV Group B aircraft. The approval was authorized, even though the company's operation manual did not include weight and balance forms for the Beaver aircraft. Transport Canada conducted a base inspection of Air Toro Incorporated in June 1985 and informed the company via letter that sample weight and balance forms for the DHC-2 were to be forwarded to Transport Canada by the end of August 1985. The company did not comply, and Transport Canada did not follow-up on the observation. In August 1986, Transport Canada conducted another base inspection and advised the company, once again in writing, of the necessity to prepare and forward weight and balance forms for the DHC-2 to the Transport Canada regional office for approval. Air Toro replied to Transport Canada in October 1986 but did not include the required weight and balance forms. There was no subsequent follow-up action by Transport Canada to either obtain the weight and balance forms from Air Toro or to suspend Air Toro's OC because of non-compliance. Consequently, Air Toro continued operations as a Class IV carrier despite evidence that commercial operations were being conducted without adequate documents to enable the safe operation of the Beaver aircraft. Therefore, the CASB recommends that:

> The Department of Transport improve procedures for the follow-up to any outstanding items from the audit of a company's operations.

CASB 88-31

4.2.2 **Pilot Proficiency**

Pilots engaged in the commercial operation of single-engined aircraft of 12,500 pounds or less are required to possess a valid commercial pilot's licence and to conduct three take-offs and landings in any preceding 90-day period. In seasonal operations such as Air Toro's, pilots of single-engined aircraft often cease flying during the winter months, conduct three take-offs and landings at the beginning of the next season, and commence commercial fare-paying operations without any form of proficiency evaluation. This contrasts with pilots who operate multi-engined aircraft commercially; they are required to complete a pilot proficiency flight check annually. Consequently, 10 or more fare-paying passengers in a large single-engined commercial aircraft may not have the same guarantee of demonstrated pilot competence as two or three passengers in a small multi-engined aircraft. This anomaly in regulatory requirements constitutes a safety deficiency.

Mr. Justice L. Dubin, in the "Report of the Commission of Inquiry on Aviation Safety" (Vol. 3) noted that many accidents involving single-engined aircraft are caused by inappropriate responses to emergencies or abnormal situations; consequently, he sought annual mandatory flight checks for commercial pilots who only fly single-engined aircraft under visual flight rules. However, no such measures have yet been introduced.

The Board recognizes that there would be logistical difficulties in introducing an annual proficiency flight test, including the requirement for more TC inspectors and the possibility of conducting flight examinations in single-engined aircraft not equipped with dual flight controls. Nonetheless, the Board believes that practical and effective methods of flight testing in single-engined commercial aircraft are possible.

American regulatory authorities require a flight review of all licensed pilots every 24 calendar months (FAR 61.57 refers), and an annual flight competency check of pilots commercially operating single- and multi-engined aircraft (FAR 135.293 refers).

Given the fact that the accident pilot had never received any form of pilot proficiency check on the Beaver and given the circumstances of this accident wherein TC inspectors had observed on a lack of "serious" company training, the Board believes that at least minimal measures to audit pilot proficiency are required.

In view of the disparity in standards between commercial single-engined and multi-engined operations concerning the verification of pilot proficiency and bearing in mind the difficulties in maintaining pilot proficiency in seasonal operations, as demonstrated during this investigation, the CASB recommends that:

> The Department of Transport institute a method of ensuring the proficiency of pilots who are engaged in the commercial operation of single-engined aircraft in VFR operations only.
>
> (CASB 88-32)

4.3 Safety Concerns

4.3.1 Float Operations

The investigation of this occurrence reconfirmed a number of practices by float operators which could have serious safety ramifications and which had been identified in previous investigations; for example, the operation of overweight float-equipped aircraft and the practice of regularly backing up the aircraft onto the shore for loading. The CASB earlier identified the need to undertake a safety study of float-equipped aircraft accidents; consequently, information from this occurrence will be used to assist in the validation of such safety deficiencies.

This report and the safety action therein has been adopted by the Chairman, K.J. Thorneycroft, and Board Members:

W. MacEachern
A. Portelance
F. Thurston

L. Filotas (abstained)
D. Mussallem (abstained)

Member N. Bobbitt dissented as follows:

The evidence has not established that the aircraft was being flown above its maximum gross weight and outside its C of G limits. Factors used in establishing the aircraft's weight included the results from a baggage survey that did not necessarily represent the baggage on this particular flight, and the assumption of approximately 160 pounds of water in an aft float compartment.

In addition to the assumed water in the aft float compartment, the C of G was partially determined on the basis of a passenger's observation of the aircraft's in-flight attitude. I do not believe that a passenger who had flown only twice previously on a Beaver aircraft would notice a slight nose-up attitude. In fact, the Beaver appears to fly nose-up to most passengers in relation to other float aircraft.

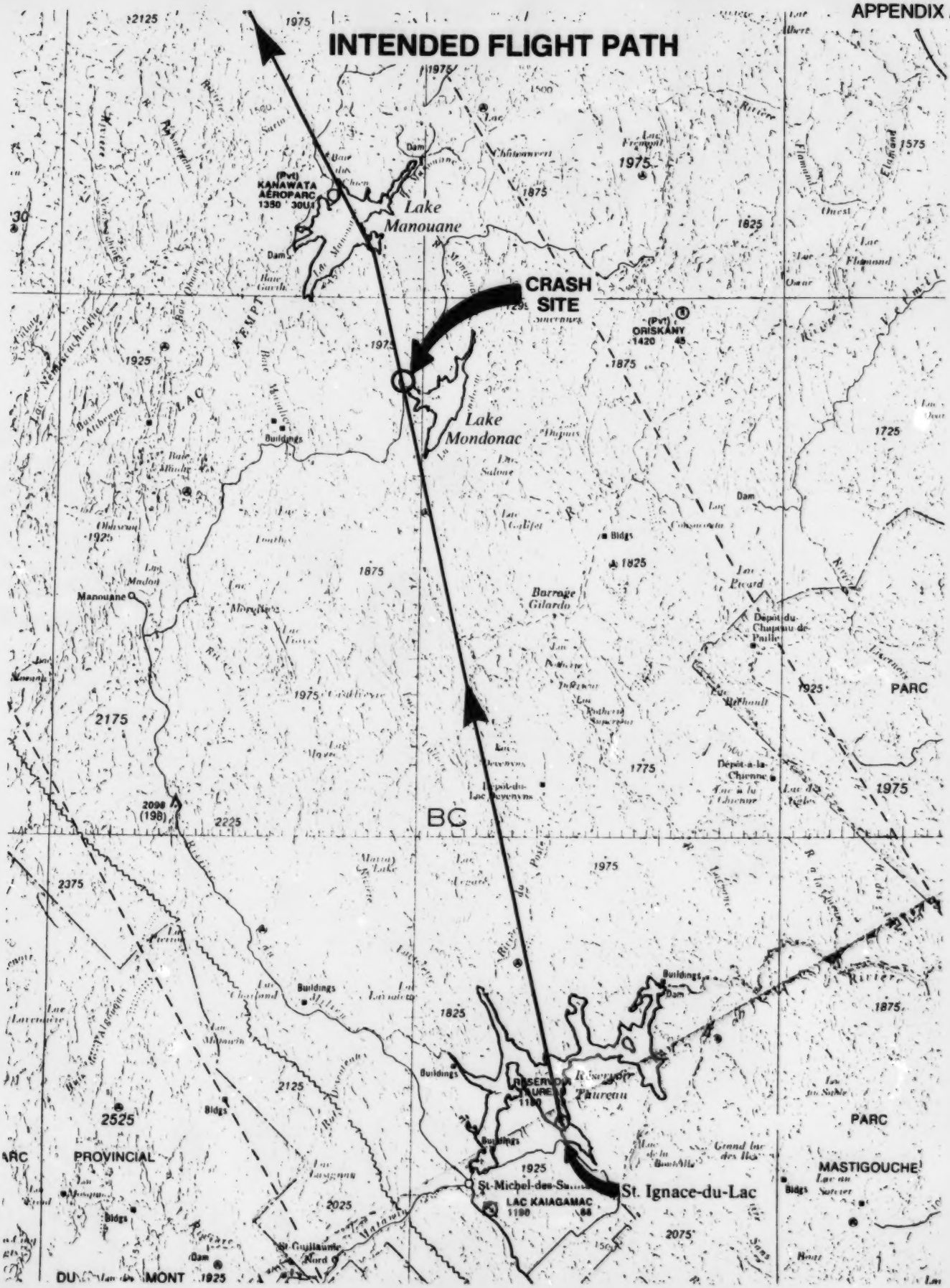
Water is assumed to have accumulated in an aft float compartment through a crack from which when tested water drained at a rate of one-quarter pound per hour. If the water seeped in at the same rate, then it would have taken approximately 26 days for the float compartment to accumulate 160 pounds. Even assuming that the water may have seeped in at a greater rate than it drained out, one still has to conclude that the floats had not been pumped out for some time prior to the accident flight. Such a conclusion is unconvincing, and, lacking any evidence to the contrary, I assume that the floats were pumped prior to the first flight each day, including the day of the accident.

Even if it had been shown that the aircraft was overweight and out of C of G, the consequences would have been more adverse during the take-off and initial climb, than in cruise flight. Also, at 45 minutes into the flight, the fuel burn would have reduced the weight and improved the C of G.

The propeller damage indicates that the engine was producing little or no power at impact. However, it was not determined if this was due to a failure or a reduction in power by the pilot.

Taking into account the above points, I conclude that the pilot lost control of the aircraft while attempting an emergency landing. The reason for the loss of control or the emergency landing was not determined.

APPENDIX A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CRASH SITE
Lake Manouane
Lake Mondonac
(Pvt) KANAWATA AERODROME
(Pvt) ORISKANY
St. Ignace-du-Lac
St-Michel-des-Saints
LAC KAIAGAMAC
Manouane
Barrage Gilardo
Réservoir Taureau
PARC
PROVINCIAL
MASTIGOUCHE
DU MONT
BC

APPENDIX B

LIST OF LABORATORY REPORTS

The following laboratory reports were completed:

LP 130/87 Engine Examination
LP 131/87 Fuel Selector Valve

These reports are available on request from the Canadian Aviation Safety Board.

APPENDIX C

GLOSSARY

ADF	automatic direction finding
agl	above ground level
AME	aircraft maintenance engineer
ANO	Air Navigation Order
asl	above sea level
CASB	Canadian Aviation Safety Board
C of G	centre of gravity
CTC	Canadian Transport Commission
EDT	eastern daylight time
ELT	emergency locator transmitter
HF	high frequency
hr	hour(s)
lat	latitude
lb	pound(s)
long	longitude
M	magnetic
N	north
OC	Operating Certificate
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite
UTC	Coordinated Universal Time
VFR	visual flight rules
VHF	very high frequency
W	west
°	degree(s)
'	minutes(s)